Safety and Efficacy of Reirradiation Stereotactic MR guided Adaptive Radiotherapy (SMART) for Locally Recurrent Non-Small Cell Lung Cancer (NSCLC) Previously Treated with Cyberknife: A Case Study

J. Conibear, V. Ezhil, H. Harford-Wright, A. Martin, A. Nash.
GenesisCare UK

Abstract

SABR has now become the international standard of care treatment for patients with early-stage NSCLC for whom surgery is not appropriate. Published studies have demonstrated 2-year survival and local control rates of 70% and 90% respectively. Patients with thoracic tumours that recur within 12 months of primary SABR irradiation are therefore uncommon and have potentially limited therapeutic options. Reirradiation of locally recurrent disease using further SABR has not been studied. Here we report on possibly the UKs first case of lung irradiation using MR guided SABR following prior SABR using Cyberknife.

Background History

A 90-year-old gentleman who originally presented with a biopsy confirmed T2a N0 M0 adenocarcinoma of the right lower lobe in March 2020. Due to cardiac co-morbidities, he was deemed not a suitable for surgery despite a performance status of 1 so was treated with SABR using fiducial tracking on Cyberknife. He received 55Gy in 5 fractions to the 60.2% isodose on alternate days. Treatment was completed on the 1st of May 2020 with evidence of good therapeutic response on PET-CT conducted 12-weeks post treatment.

In May 2021, the patients repeat PET-CT scan revealed increased soft tissue and intense FDG activity at the original site of disease near to the proximal bronchial tree. A CT guided biopsy confirmed viable adenocarcinoma, so, based on the fact the patient remained PS 1 and was keen for further treatment, they were referred for re-irradiation SABR to the site of local recurrence utilising MRIdian MRI linac technology.

SMART Treatment Planning and Delivery

The plan was to deliver 60Gy in 8 fractions on alternate days. Before each fraction, a 3D-MR was acquired in breath-hold to define the patient's anatomy on the day. Rigid registration of the tumour and deformable registration of the OARs was performed, and the supervising clinician edited the tumour and OARs to account for any daily variation. The original plan was applied to the new contours and the plan was then re-optimised to improve target coverage whilst keeping the thoracic OARs within the recommended tolerances. Patient specific QA was performed and dosimetric data was recorded on target coverage and OAR tolerances on the base plan and at each fraction for the predicted plan and re-optimised plan for analysis.

Each fraction of treatment was delivered using real time gated delivery in breath hold. The patient tolerated the treatment very well and successfully completed their second course of lung SABR on the 30th of July 2021. Six-weeks post treatment the patient had not experienced any acute toxicities and their twelve-week post SABR PET-CT scan revealed reduced soft tissue and FDG activity (SUVmax 5.1, previously 8.6) at the site of re-irradiation.

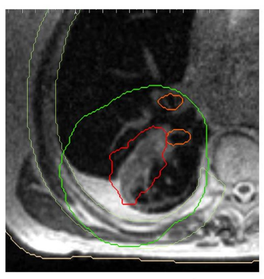


Image 1: Proximal bronchial tree abutting/overlapping with PTV

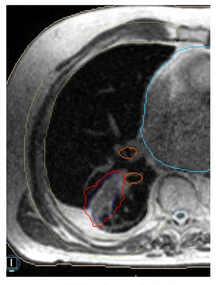


Image 2: GTV (blue) and PTV (red) abutting PBT

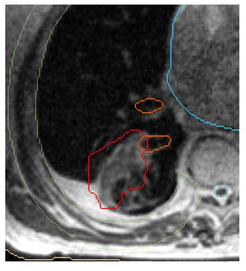


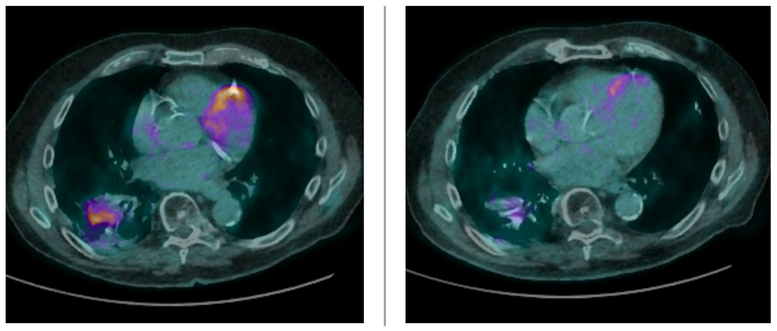
Image 3: PTV overlapping with PBT

Measure	Base plan	Fraction1	Fraction2	Fraction3	Fraction4	Fraction5	Fraction6	Fraction7	Fraction8
PTV V60 (Gy)	74.79	5.06	73.88	78.65	78.4	69.56	80.91	82.71	87.68
PTV Mean (Gy)	63.03	53.05	62.54	63.6	63.71	61.75	64.18	65.08	66.15
GTV 0.1cc Max	79.15	67.7	74.5	74.33	80.98	76.16	75.72	82.29	78.38
PBT_3cm 0.5cc Max (≤13Gy)	12.85	11.67	12.98	12.89	13	13	12.13	13	12.85
Lungs-GTV V20 (≤10%)	10.00%	10.00%	10.00%	10.00%	9.09%	10.73%	10.00%	9.04%	10.00%
Heart 0.5cc Max (≤44.9)	25.57	22.2	22.59	23.34	25.59	23.32	25.32	23.88	26.32
Spinal Cord PRV 0.1cc max (≤23Gy)	2.21	2.19	1.99	2.03	2.05	1.94	2.25	2.2	2.13

Discussion

This is believed to be UKs first case of using SMART for the delivery of re-irradiation SABR to treat a 90-year-old patient with locally recurrent NSCLC following failure of primary SABR treatment using Cyberknife.

This case demonstrates that SMART allows for the safe delivery of complex thoracic retreatments by keeping the thoracic OAR tolerances within departmental limits for every fraction of treatment in addition to allowing optimal target dosimetry by accounting for daily variation in the position of nearby organs at risk, thereby increasing the therapeutic index. Breath-hold delivery also reduces the volume of lung treated thereby reducing dose to the lung which is of particular importance in the case of utilising SABR for reirradiation of primary lung cancer.



Pre-MRL SABR PET-CT vs. Post-MRL SABR PET-CT

Conclusion

Recent advances in linac technologies for SABR delivery, particularly the integration of MR imaging, has opened the door for ground-breaking opportunities in the safe delivery of reirradiation to complex intrathoracic targets. SMART, by providing optimal soft tissue visualisation of both tumour target and OARS, plus daily re-contouring and plan adaptation combined with real time breath hold gated delivery appears to provide a safe and effective platform to deliver complex reirradiation SABR safety and effectively to the thorax.

References:

1. Murray P, Franks K, Hanna GG. A systematic review of outcomes following stereotactic ablative radiotherapy in the treatment of early-stage primary lung cancer. Br J Radiol. 2017 Mar;90(1071):20160732. doi: 10.1259/bjr.20160732. Epub 2017 Feb 17. PMID: 27885858; PMCID: PMC5601509.
2. Trakul N, Harris JP, Le QT, Hara WY, Maxim PG, Loo BW Jr, Diehn M. Stereotactic ablative radiotherapy for reirradiation of locally recurrent lung tumors. J Thorac Oncol. 2012 Sep;7(9):1462-5. doi: 10.1097/JTO.0b013e31825f22ce. PMID: 22895143.